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THE TRANSPORTATION OF SWEET CHERRIES UNDER REFRIGERATION AND REFRIGERATION SUPPLEMENTED WITH CARBON DIOXIDE GAS

Tests made in cooperation with Yakima Valley shippers, Northern Pacific Railroad, Chicago, Burlington and Quincy Railroad, and The Sisalkraft Company.

From Yakima, Wash., to Minneapolis, Minn., Chicago, Ill., and Pittsburgh, Pa. June 30 to July 8, 1938.

By

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Washington, D. C.
September 15, 1938

THE TRANSPORTATION OF SWEET CHERRIES UNDER REFRIGERATION AND REFRIGERATION SUPPLEMENTED WITH CARBON DIOXIDE GAS

Report of Test Trip Wash. 1938-1
June 30 to July 8, 1938

INTRODUCTION

Studies on the storage of sweet cherries have shown that when stored in atmospheres containing 15 and 25 percent carbon dioxide gas at 40° F. the fruit remained brighter and was subject to less decay than when stored in air, and flavor was unimpaired. Cherries stored in the higher concentrations of gas at 40° remained in better condition than when stored in air at 32°. It has also been ascertained that sweet cherries can be held in concentrations of carbon dioxide gas up to 40 percent for three weeks at 45° without injury to the fruit. Sweet cherries shipped from the Pacific Northwest to eastern markets are ordinarily subjected to temperatures of 40° or higher in some parts of the load and if they move by freight with slower train schedules than by express, the continuance of these temperatures may result in sufficient deterioration to make freight shipments more or less hazardous.

Believing that through the use of carbon dioxide in transit the hazards of shipping sweet cherries by freight could be greatly reduced, studies were made during the seasons of 1935, 1936, and 1937 on the possibility of maintaining desired concentrations of the gas in refrigerator cars. In these experiments the movement was over short distances and the cars were loaded with apples without ice. In addition, similar experiments were conducted in cars not loaded,

with and without ice. The studies showed that the loss of carbon dioxide gas from refrigerator cars under movement was so great that it was difficult to build up a gas concentration above 20 percent and that this concentration was not maintained for longer than a few hours.

The work during these years showed that if the principle of using carbon dioxide is to be applied to rail shipments, means had to be devised either to seal the cars to insure retention of the gas or the supply had to be replenished in amounts sufficient to offset the loss due to leakage.

Sweet cherries generally bring a higher price on the auction markets in the east when they are bright in appearance. Red cherries appear brighter and seem to sell better than black cherries. In order to secure the desired bright red cherries many Pacific Coast shippers have demanded that black varieties of cherries be picked before they are mature enough to have good eating quality. Laboratory experiments have shown that sweet cherries keep brighter, with greener, fresher stems, when held in carbon dioxide than when held in air. The most urgent need for application of these laboratory findings therefore appeared to be in the commercial adaptation of the principle of using carbon dioxide as a supplement to ice refrigeration in the transportation of properly matured sweet cherries to terminal markets.

OBJECTS

A transportation test, involving the use of carbon dioxide gas in the carlot shipment of sweet cherries from Yakima, Washington, to eastern terminal markets, was made between June 30 and July 8, 1938. This test was conducted over the Northern Pacific, Chicago Burlington & Quincy, and the Pennsylvania railroads. The objects of this test were to develop

information relative to: (1) methods of gas-proofing refrigerator cars, (2) methods of releasing carbon dioxide gas, (3) rate of sublimation of solid carbon dioxide within the test cars, (4) air and fruit temperatures in the car, (5) the influence of carbon dioxide on refrigeration in transit, (6) the influence of carbon dioxide gas on the color and condition of the fruit, (7) the retention of the gas and concentrations of it that may be anticipated in present refrigerator car equipment, and (8) the relation between maturity of cherries and carbon dioxide gas treatments in transit, and the condition of the fruit upon arrival at market destination.

OUTLINE OF TEST

Description of Cars

In order to obtain uniformity in refrigerator car construction, five new express cars of a single series (NRC-700) were used. These cars were of steel construction with wooden interiors. They carried 4 inches of insulation on the sides and 4-1/2 inches on the top and bottom. They had a bunker capacity of 12,900 pounds of ice, while their total cubical capacity was 3,240 cubic feet. All were equipped with wire basket ice bunkers, and floor racks, which in all cars except Car A were temporarily raised on stringers 4 inches above the wearing floor.

Car A - NRC-711 Bunkers were removed and the entire inner surface of the car was lined with an asphaltum paper in which Sisal fibers were embedded (Sisalkraft). The paper surfaces were glued together at the seams with a casein-ammonia-rubber cement. Ice bunkers were then re-installed. Solid carbon dioxide was carried in a crib in the bracing. (See Table 2)

Car B - NRC-702 Inside walls and ceiling were coated with an odorless, tasteless, colorless, emulsified mineral oil. The material was applied in a uniform film by means of an electrically driven spray gun. Solid carbon dioxide was carried in a wooden crib in the bracing. (See table 2).

Car C - NRC-724 This car received no gas-proofing. One galvanized double-walled, metal, solid carbon dioxide bunker 11 feet long and 12 inches square, in cross section, was suspended from the ceiling at alternate ends of the car. (See table 2).

Car D - NRC-705 No gas-proofing for interior of the car. Solid carbon dioxide was carried in two wooden cribs, one at each end of the car at the bunker. The cribs were suspended across the car about two feet above the load. (See table 2).

Car E - NRC-704 Check car.

The solid carbon dioxide cribs in Cars A and B were located on top of the center bracing above the top level of the load. The dry ice was placed in all cars on the morning of June 30, subsequent to loading. Special attention was directed toward the proper functioning of the water-seals and hatch-plugs in all of the test cars.

Location of Electric Resistance Thermometers

Air Temperature

Bottom air; center line; doorway

Top " " " "

Bottom " " " bunker at floor rack

Top air; center line; bunker at screen

Top " twelve inches under carbon dioxide container of cars C and D; about 24 inches below top bunker opening at 6 inches from south wall.

Fruit Temperature

Bottom fruit center doorway

Top " " "

Bottom " " quarterlength

Top " " "

Bottom " " bunker

Top " " "

" " south side car at doorway

Thermometers were not inserted in the flesh of the cherries but were buried among the fruits at the centers of packages.

Removal of Air Samples for Gas Analysis

Air samples for gas analysis were obtained from the ceiling and floor-rack levels at the quarterlength positions. They were taken through a line of one-quarter inch rubber tubing connected to copper tubing which extended through the doorway. The percent of carbon dioxide in these air samples was determined by means of an Orsat gas analyzing apparatus.

Test Boxes of Fruit for Examination at Destination

To obtain comparable fruit for inclusion in the different cars, cherries were harvested from a single group of trees in one orchard a day prior to the loading of the test cars. The fruit was graded as to color into two lots - bright red and dark red, representing two stages of maturity

commonly encountered in commercial shipments. One standard 15-pound cherry lug box of each maturity was loaded at the same position in each test car. In addition, each car contained one 5-pound box of stemless fruit which had been immersed in a bath containing blue mold spores. All test boxes were carried on top of the load at the bracing.

Fruit loading data.

Table 1. Loading data for cars of sweet cherries in test Wash. 1938-1.

Item	Car A	Car B	Car C	Car D	Car E
Shipper	Hort. Union	Perham	Hort.Union	Pacific	Big Y
Loading point	Yakima	Zillah	Naches	Yakima	Gleed
Destination	Minn.	Chicago	Chicago	Dallas	Pittsburgh
Date Loaded	6/30	6/29	6/29	6/30	6/29
Time started	7:20 A	3:30 P	3:30 P	7:00 A	4:30 P
Time finished	9:40 A	6:00 P	7:15 P	9:00 A	6:15 P
Car temperature - start	47° F.	35° F.	40° F.	40° F.	33° F.
Car temperature - close	49°	34°	52°	47°	35°
Fruit temperature	31°-32°	31°-34°	32°-33°	32°-33°	32°-33°
Fruit variety	Bing	Bing	Bing	Bing	Bing
Number of packages 1/	1528	1512	1528	1070 2/	1584
Packages	17½ lb.	17½ lb.	17½ lb.	Mixed	17½ lb.
Layers high at bunker	7	7	7		7
Layers high at doorway	6	6	6		6

1/ Exclusive of test boxes.
2/ Car D contained 200 lugs of 17 1/2 lbs. and 800 lugs of 28 lbs.

Unsettled shipping conditions made it impossible to complete arrangements for inclusion of some of the cars until only a few hours before loading started and it was impossible to manage all of the details as desired. As a result, there were the following variations in loading conditions, not shown in table 1.

Car A had paper applied over the bottom bunker openings above the floor racks and extending over the floor racks to a distance of about five feet from the bunker bulkheads. No lath was placed on the floor racks. Fruit was carried from storage to car through a small wooden tunnel, with canvas covering the remainder of the car door opening. A weak air cuttent passed through the tunnel from the cold storage to the car. Packages were stripped on the 3rd, 6th and top layers.

The fruit load had been assembled over several days and no cherries were in the cold storage rooms less than 36 hours. Packages examined showed satisfactory fruit maturity. Occasional fruits were found with rain-cracks, a few of which had started to decay.

Car B had paper applied on the floor racks at the bottom bunker openings as in car A. Lath, running lengthwise of the car and packages, was placed on the floor racks to prevent the cleats on the packages from dropping into the cracks of the floor racks and to save the lids (faces of packages being loaded downwards in all cars) from resting directly on the floor racks. A ply-wood tunnel, the full size of the car doorway, was affixed between the storage and the car. Salt had been applied to the ice two hours prior to loading and car precooler fans were operated approximately two hours prior to opening the car for loading, during the loading period and for approximately two hours after loading was completed. Packages were stripped on the 3rd, 6th and top layers.

The fruit load had been assembled over several days and no cherries were in the cold storage rooms less than 24 hours. The fruit in many boxes appeared rather immature, being bright red in color. Many fruits were rather soft. Some rain-cracks were evident and an occasional cherry showed slight mold growth.

Car C was not supplied with paper on the floor racks at the bunkers or with lath beneath the fruit packages. Fruit was carried from storage to car through a small wooden tunnel, with burlap covering the balance of the car door opening. Refrigeration carried through the tunnel from the cold storage did not appreciably influence the temperature within the car while loading. Packages were stripped on the 2nd, 4th and top layers.

The fruit load had been assembled over several days and no cherries were in the cold storage room less than 36 hours. The fruit in the packages examined showed satisfactory maturity. Occasionally a cherry was found with rain-cracks.

Car D had paper applied on the floor racks at the bunker openings and had strips placed beneath the packages as in car B. Fruit was conveyed from the storage to the car through a ply-wood tunnel which was the size of the car door opening. Air, at a temperature of 32°-34° F., was blown from the cold storage room, but the size of the conveyor opening from the storage, as well as tunnel conditions, prevented this from markedly influencing the temperature of the car during loading. The 17 1/2 pound packages were stripped on the 2nd, 4th and top layers.

The fruit load had been assembled over several days and no cherries were in the cold storage rooms less than 24 hours. As only air temperatures were to be recorded in this car the fruit packages were not opened for examination.

Car E had paper applied on the floor racks at the bunker openings and strips placed beneath the packages as in car B. Fruit was loaded by trucking through a wooden tunnel fitted to the full size of the car door. Fans with airplane-type propellors blew a strong air blast from the storage into the car during loading. The air had a temperature of 28° F.

as it left the storage. Packages were stripped on the 2nd, 4th and top layers.

The fruit load was assembled over several days and no cherries were in the cold storage less than 24 hours. The packages examined contained fruit of satisfactory maturity.

The loads in all cars were braced at the doorways.

Variations in car refrigeration.

The principal object in securing a record of the temperatures in transit was to observe the effect upon car refrigeration of the sublimation of the dry ice and the maintenance of carbon dioxide gas within the cars. It was desired to observe the effect upon the car refrigeration of placing the dry ice (a) above the car bracing at the center of the car, (b) adjacent to the ice bunkers and (c) in longitudinal metal bunkers above the load. It was not possible to dissuade all shippers from their usual refrigeration practices in order to have all cars shipped under uniform icing instructions so that the following variations in refrigeration occurred.

Car A was fully iced June 28 and reiced June 29; 4 percent salt was added to the ice after loading was completed at 9:40 A. M. June 30. After reicing at Spokane the use of salt was discontinued for the balance of the transit period to reduce the danger from freezing.

Car B was fully iced June 28 and reiced June 29; 4 percent salt was added to the ice at 1:30 P. M. June 29, two hours prior to loading. Car precoolers were installed immediately after adding the salt and were operated until 8:00 P. M. Four percent salt was used at all reicings in transit.

Car C was fully iced on June 28 and reiced on June 29; 4 percent salt was added to the ice after loading was completed at 7:15 P. M. June 29, and at all reicings excepting Laurel, where the percentage was reduced to 3 percent.

Car D was fully iced on June 28 and reiced on June 29; 4 percent salt was added to the ice at 10:00 P. M. June 29, nine hours prior to the time of loading the car. Four percent salt was used at all reicing stations.

Car E was fully iced on June 28 and reiced on June 29; 5 percent salt was added to the ice after loading was completed at 6:15 P. M. June 29 and at all reicing stations in transit.

Observations Made En route and at Destination

Fruit and air temperatures were obtained at frequent intervals en route by means of electric resistance thermometers. During transit icing records were kept, and determinations were made of the carbon dioxide content of the atmosphere within the test cars. Observations were made at destination on the fruit in the test boxes. They included notes on the color, condition, and percentage of decay in the various lots. Comparisons were also made of the general appearance of the fruit from the various cars.

PRESENTATION OF RESULTS

The results will be presented under three headings, i.e.

a) Sublimation of solid carbon dioxide and its gaseous concentration in transit.

b) Refrigeration in transit.

c) Condition and appearnace of fruit at destination.

SUBLIMATION OF SOLID CARBON DIOXIDE AND ITS GASEOUS CONCENTRATION IN TRANSIT

After completion of loading, solid carbon dioxide was added to the refrigerator cars according to the methods outlined in Table 2. Previous results have shown that it is possible to effect a rapid accumulation of carbon dioxide within the cars by the addition of crushed cakes of solid carbon dioxide to the water ice in the bunkers. Due to super cooling, this procedure, however, produces some channeling of the water ice. From Table 2 it can be seen that, depending upon the duration

Table 2. Application and Sublimation of Solid Carbon Dioxide in Refrigerator Carloads of Sweet Cherries from Yakima to Chicago. 1938

of the transit period, from 430 to 900 pounds of solid carbon dioxide were sublimated per car. This amount of sublimation was many fold greater than would have been necessary had there been no gas leakage from the cars during transit. For example, in Car D, 432 pounds of solid carbon dioxide were sublimated in 60 hours and the atmospheric concentration of this gas averaged about 11-12 percent during this period. Had there been no escape of gas from the car, it would have required the sublimation of less than 40 pounds of solid carbon dioxide to yield a similar concentration of this gas. This statement is based on the fact that one pound of solid carbon dioxide will liberate 9 cubic feet of gas and that the cubic capacity of the car is approximately 3,240 feet. Therefore, the reserve solid carbon dioxide requirement for this car was approximately eleven times greater than would have been necessary had no leakage occurred. This situation emphasizes the need for reducing the leakage of gas from refrigerator cars if maximum benefits are to be obtained from the transportation of fruits and vegetables in atmospheres of carbon dioxide.

Table 2. Application and Sublimation of Solid Carbon Dioxide in Refrigerator Carloads of Sweet Cherries from Yakima to Chicago, 1938.

Car	Initial amount of solid CO_2 added to water ice in bunkers (cakes crushed)	Initial amount of solid CO_2 added in unopened 100-lb heavily insulated shipping cartons	Position of cartons in refrigerator	Addition of solid CO_2 on water ice en route	Total amount of solid CO_2 added per car	Total amount of residual solid CO_2 per car at destination	Total amount of sublimation during test	Average sublimation rate of packaged cakes $\frac{\text{Lbs. } CO_2}{\text{Hr.}}$	Average sublimation rate per 100 lb. unopened carton per hr.
	lbs	lbs		lbs	lbs	lbs	lbs		
(A) NRC 711	144	768	wooden crib in bracing	none	912	357	555	3.65	0.45
(B) NRC 702	144	768	wooden crib in bracing	320	1232	318	914	3.38	0.42
(C) NRC 724	144	768 in uninsulated 50-lb cakes	metal CO_2 bunkers at opposite ends of car	none	912	20	892	6.70	-
(D) NRC 705	144	768	wooden racks above load at each bunker	none	912	480	432	4.80	0.60

The sublimation rates of all the packaged cakes of solid carbon dioxide are also given in Table 2. The rate was twice as high in the steel "dry ice" bunker as from the heavily insulated shipping cartons in the crib at the bracing. The sublimation rate was also considerably higher in the shipping cartons when free access to air was possible as in Car D.

In table 3 and figure 1 are presented the data on the concentrations

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Table 3. Percent Carbon Dioxide in Refrigerator Cars Loaded with Sweet Cherries. 1938.

Figure 1. Carbon Dioxide Concentration within Refrigerator Cars of Sweet Cherries En route from Yakima, Washington, to Chicago, Illinois.

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of carbon dioxide obtained in the various test cars en route. Car A (lined with Sisalkraft paper) retained the highest concentration of gas; if the rate of sublimation could have been increased, even higher concentrations of gas might have been obtained. Evidently the rate of sublimation in this car must have approximated the rate of leakage between the 18th and the 67th hours, since during this time the concentrations of gas varied but little.

Car B (greased) retained disappointingly low concentrations of carbon dioxide. Evidently this car was a "leaker" and visual inspection lent emphasis to this conclusion. Door seals and bunker fittings were none too tight. The addition of 320 pounds of solid carbon dioxide to this car at Laurel, Montana, resulted in a temporary increase of the atmospheric carbon dioxide gas for only about 30 hours. It appears that a large variation in gas-tightness exists between new refrigerator cars of the

Table 5. Percent Carbon Dioxide in Refrigerator Cars Loaded with Sweet Cherries. 1938

Station	Date	Time	Hours from adding solid CO_2	Car A NRC 711 Paper lined solid CO_2 in bracing		Car B NRC 702 Inside surface coated with oil emulsion CO_2 in bracing		Car C NRC 724 Not gas-proofed. Two metal CO_2 bunkers opposite ends of car		Car D NRC 705 Not gas-proofed CO_2 in wooden racks each end of car above load		Remarks
				bottom	top	bottom	top	bottom	top	bottom	top	
Yakima	6/30	11:30 A	1.5	13	13	15	13	16	15	14	14	
"	"	1:30 P	3.5	20	20	16	15	17	17	17	17	
Gibbon	"	4:30 P	6.5	22	22	14	12	17	17	17	--	
Pasco	"	7:00 P	9.0	19	17	10	10	13	13	13	13	
Lind	"	11:30 P	13.5	17	17	10	9	13	12	12	12	
Yardley	7/1	4:00 A	18.0	16	16	9	8	12	12	11	11	Before re-icing
"	"	4:45 A	18.7	14	14	9	8	12	12	11	11	After re-icing
Kootenai	"	11:00 A	25.0	14	14	8	7	12	12	11	11	
Paradise	"	5:30 P M.T.	31.5	13	13	7	7	12	12	11	11	
Missoula	7/2	12:15 A	37.2	14	13	7	6	12	10	11	11	Rough jolting
Austin	"	7:30 A	44.5	16	15	9	7	14	14	13	12	over Cont.
Helena	"	10:00 A	47.0	15	15	9	7	--	13	--	--	Divide.
Bozeman	"	2:30 P	51.5	15	14	7	6	12	12	11	10	
Livingston	"	6:00 P	55.0	15	14	8	6	12	12	11	11	
Laurel	"	12:00 M	61.0	14	13	16	14	11	12			320 lbs. CO_2
Custer	7/3	3:30 A	64.5	--	--	18	15	--	--			added on ice
Forsyth	"	6:30 A	67.5	14	13	19	18	11	11			in bunker
Miles City	"	9:15 A	70.2	--	--	17	14	--	--			11:00 PM
Glendive	"	12:00 N	73.0	11	11	13	13	8	8			Car B
Dickinson	"	7:00 P	80.0	11	10	11	9	9	9			
Glen Ullen	"	11:00 P	84.0	10	9	9	8	8	8			
Windsor	7/4	C.S.T. 7:00 A	91.0	10	9	9	8	8	8			
Dilworth	"	3:00 P	99.0	10	8	3	3	6	6			Before re-icing
"	"	5:00 P	101.0	8	8	-	-	6	6			After re-icing
Staples	"	9:30 P	105.5	9	8	5	4	5	5			
Northtown	7/5	4:30 A	112.5	9	8	5	3	5	4			
Winona	"	11:30 A	119.5			3	2	3	3			
Savanna	"	6:30 P	126.5			3	2	2	2			
Morton Park	7/6	1:00 A	133.0			3	2	2	2			

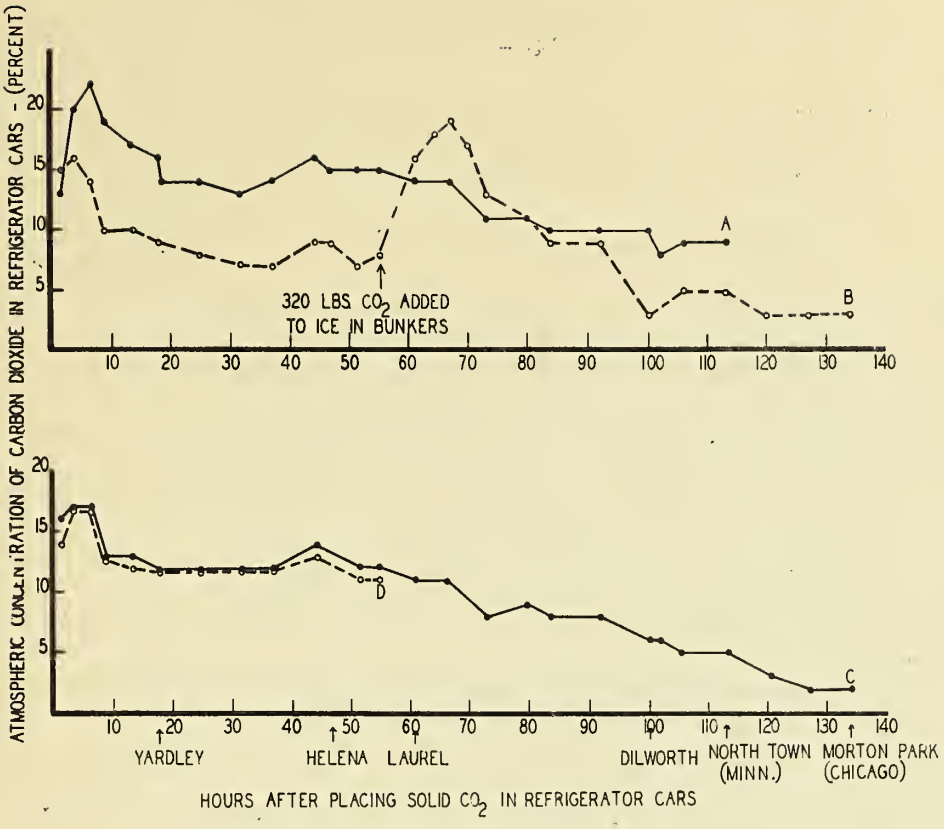

FIGURE 1 Carbon Dioxide Concentration within Refrigerator Cars of Sweet Cherries En route from Yakima, Washington, to Chicago, Illinois.

Car A - Lines with Sisalkraft paper. Carbon dioxide in wooden crib at the bracing.

Car B - Inside surface of car coated with grease. Carbon dioxide in wooden crib at the bracing.

Car C - No gas-proofing. Carbon dioxide in double walled metal "dry ice" bunkers suspended from ceiling at alternate ends of the car.

Car D - No gas-proofing. Carbon dioxide in wooden racks at each bulkhead about 2 feet above the load.

same series. Greasing of the interior surface of the car in the loading space, in the opinion of the observers does not warrant further study, since the lightness of application and the inability to treat the bunker surfaces leaves the gas-proofing problem unsolved.

Re-icing of the gas cars in transit was accomplished by opening one bunker plug at a time. Table 3 shows that the higher the concentration of carbon dioxide gas within the car the greater was the gas loss during re-icing. Rough handling and jolting of the cars increased the sublimation rate and resulted in higher gaseous concentrations of carbon dioxide. This was especially true between Missoula and Helena, Montana, where the Continental Divide was traversed and the jolting of the cars at the rear of the train was the most severe. (See fig. 1).

REFRIGERATION IN TRANSIT

Temperature records during transit are given in tables 4, 5, 6, 7, and 8. Ice and salt data are shown in table 9. Weather observations are given in table 10.

Table 4. Temperatures in Transit Car A: Paper lined - Dry ice in bracing.

Table 5. Temperatures in Transit Car B: Oil coated car - Dry ice at bracin

Table 6. Temperatures in Transit Car C: Metal dry ice bunkers - no sealir

Table 7. Temperatures in Transit Car D: Dry ice bulkhead above load.

Table 8. Temperatures in Transit Car E: Check car.

Table 9. Ice and Salt used in transit.

Table 10. Weather Observations.

Table 4. Temperature in transit. Car A: Paper lined - Dry ice in bracing

Place	Date	Time	Outside temp	Air					Bruit						
				Doorway		Bunker		Beneath Bulkhead Opening (1)	Doorway		Bunker		Quarter-length		Top doorway south side car
				Top	Bottom	Top	Bottom		Top	Bottom	Top	Bottom	Top	Bottom	
Yakima	6/30	11:30 A	86	37.2	30.4	36.9	-	37.0	30.9	-	33.6	30.9	-	30.9	33.3
do	"	1:45 P	83	36.1	26.8	36.3	-	35.9	32.7	-	34.8	32.1	-	32.3	34.1
Pasco	"	6:40 P	71	33.9	23.9	33.9	-	33.5	32.1	-	34.1	30.5	-	30.6	34.0
Lind	"	11:20 P	61	32.0	22.2	32.1	-	31.4	31.4	-	33.4	28.7	-	28.7	33.0
Yardley	7/1	3:50 A	55	31.0	22.0	31.0	-	29.8	30.7	-	32.5	27.3	-	27.0	32.5
" After icing	"	5:00 A	56	31.0	22.0	30.8	-	30.1	30.6	-	32.5	27.1	-	26.8	32.5
Kootenai	"	11:00 A	65	30.0	21.6	30.6	-	29.8	30.1	-	31.5	26.4	-	25.8	31.2
Paradise	"	5:25 P	61	30.8	21.9	31.3	-	30.1	29.5	-	30.6	26.1	-	24.9	30.5
Missoula	7/2	12:15 A	55	30.7	22.5	30.8	23.5	29.5	29.5	26.9	30.3	26.5	-	25.5	30.5
Austin	"	7:30 A	61	30.3	22.6	30.2	-	29.0	29.3	-	29.9	26.7	-	26.5	30.6
Bozeman	"	2:20 P	67	32.0	23.4	32.3	-	31.1	29.3	-	30.6	26.5	-	26.5	30.8
Livingston	"	5:50 P	63	32.9	23.8	33.0	-	31.5	29.6	-	29.9	26.8	-	27.0	31.1
Laurel	"	11:30 P	57	32.1	24.4	32.7	-	31.6	29.4	-	29.6	26.5	-	26.5	31.5
Forsyth	7/3	6:15 A	60	31.7	24.9	32.7	-	31.2	29.9	-	29.8	26.7	-	26.9	31.8
Glendive	"	11:50 A	88	34.7	25.6	36.3	26.7	34.9	30.3	27.4	30.2	27.0	-	27.0	32.3
Dickenson	"	7:00 P	84	38.1	27.6	39.9	28.1	38.2	32.2	27.6	32.4	27.3	-	27.5	34.2
Glen Ullen	"	11:00 P	68	37.7	28.0	39.4	28.5	37.8	32.9	28.0	32.8	27.2	-	27.5	35.1
Windsor	7/4	7:00 A	72	37.0	27.5	38.5	28.4	37.1	33.2	27.5	32.9	26.5	-	28.3	35.7
Dilworth	"	4:00 P	88	38.5	29.2	39.7	29.5	38.4	34.5	28.1	34.1	27.2	-	28.6	36.9
Staples	"	9:15 P	74	40.0	29.7	41.2	29.7	39.5	35.6	28.3	34.9	27.5	-	29.5	37.0
Northtown	7/5	4:30 A	68	39.2	30.9	39.8	29.6	38.4	35.4	28.2	35.3	27.2	-	30.3	38.5

(1) In a position comparable to that beneath dry ice bunkers in cars C and D.

Table 5. Temperature in transit. Car B: Oil-coated car - Dry ice at bracing.

Place	Date	Time	Outside temp	Air					Fruit						
				Doorway		Bunker		Beneath bulkhead opening (1)	Doorway		Bunker		Quarter-length		Top doorway, south side car.
				Top	Bottom	Top	Bottom		Top	Bottom	Top	Bottom	Top	Bottom	
Yakima	6/30	11:30 A	86	27.0	23.6	32.0	23.6	-	32.1	26.5	30.6	27.2	33.0	31.5	31.9
Do	"	1:45 P	83	27.7	25.9	34.3	24.6	-	32.0	24.6	31.3	27.4	34.8	30.9	32.6
Pasco	"	6:40 P	71	28.6	24.8	33.5	25.4	-	32.2	24.0	31.5	27.7	34.0	29.9	32.4
Lind	"	11:20 P	61	28.5	24.9	32.5	25.6	-	32.1	26.0	31.1	27.5	33.5	29.4	32.5
Yardley	7/1	3:50 A	55	28.8	25.3	31.6	26.3	-	31.7	28.0	30.9	27.6	32.9	29.2	32.6
" After icing	"	5:00 A	56	29.0	25.1	31.5	26.2	-	31.2	-	30.5	27.5	33.0	29.0	32.5
Kootenai	"	11:00 A	65	29.0	25.4	32.0	26.1	-	31.4	27.5	30.4	27.8	33.3	29.3	32.3
Paradise	"	5:25 P	61	29.7	25.6	32.9	26.4	-	31.1	-	30.3	27.4	33.1	29.0	32.8
Missoula	7/2	12:15 A	55	29.9	26.2	32.0	26.5	-	31.5	-	30.1	27.5	33.4	29.1	32.6
Austin	"	7:30 A	61	28.9	25.9	31.1	26.6	-	30.9	-	30.0	26.6	32.4	28.1	32.6
Bozeman	"	2:20 P	67	29.7	27.0	34.0	27.2	-	31.4	26.7	30.6	27.7	32.8	29.5	32.9
Livingston	"	5:50 P	63	30.0	27.2	33.9	27.3	-	31.6	27.0	30.9	27.7	33.1	29.7	33.1
Laurel	"	11:30 P	57	29.2	26.6	33.6	27.3	-	31.9	26.5	31.0	27.8	33.2	29.5	33.5
Forsyth	7/3	6:15 A	60	30.1	27.2	33.1	27.5	-	32.0	27.5	31.3	27.6	33.4	29.5	33.5
Glendive	"	11:50 A	88	30.8	27.9	36.3	28.2	-	32.3	27.4	31.7	27.9	33.4	29.9	33.7
Dickenson	"	7:00 P	84	32.7	29.7	40.2	29.0	-	34.3	27.0	33.7	28.2	35.6	30.3	36.1
Glen Ullen	"	11:00 P	68	33.0	29.6	39.5	29.0	-	34.6	26.9	34.1	28.1	36.1	30.2	36.2
Windsor	7/4	7:00 A	72	32.8	30.0	37.8	29.3	-	34.7	26.1	34.2	27.9	35.3	30.4	36.6
Dilworth	"	4:00 P	88	33.7	31.0	41.8	30.2	-	35.3	27.5	35.0	28.6	36.9	32.4	38.4
Staples	"	9:15 P	74	33.5	31.4	39.9	30.2	-	36.0	27.1	35.5	28.5	37.4	31.6	37.8
Northtown	7/5	4:30 A	68	33.6	31.4	38.4	30.1	-	35.5	-	35.9	28.6	37.5	31.9	38.3
Winona	"	11:15 A	84	33.6	33.7	39.0	30.4	-	35.8	-	35.3	28.5	37.4	32.1	37.7
Savana	"	6:45 P	84	34.0	32.6	41.4	30.9	-	37.0	-	37.0	28.6	38.5	32.9	39.0
Morton Park	7/6	1:00 A	69	34.1	32.3	40.0	31.0	-	36.6	-	37.5	28.9	39.5	33.0	39.7

(1) In a position comparable to that beneath dry ice bunkers in cars C and D.

Table 6. Temperatures in transit. Car C: Metal dry ice bunkers - no sealing

Place	Date	Time	Outside temp	Air					Fruit						
				Doorway		Bunker		Under CO_2 Container	Doorway		Bunker		Quarter-length		Top doorway south side car
				Top	Bottom	Top	Bottom		Top	Bottom	Top	Bottom	Top	Bottom	
Yakima	6/30	11:30 A	86	34.1	26.4	33.6	23.6	33.1	36.2	33.5	35.2	28.9	35.9	31.9	36.9
do	"	1:45 P	83	33.4	26.0	33.9	23.7	33.1	36.0	33.0	34.8	28.6	35.9	31.3	36.9
Pasco	"	6:40 P	71	33.0	26.0	33.8	24.4	33.0	35.7	31.8	34.3	27.0	35.3	30.4	36.5
Lind	"	11:20 P	61	31.7	26.0	32.5	24.6	31.7	34.6	30.5	33.5	27.7	34.5	29.1	35.6
Yardley	7/1	3:50 A	55	31.0	26.2	31.5	25.0	30.6	33.9	29.5	32.5	27.5	33.5	28.5	34.9
" After icing	"	5:00 A	56	31.4	26.4	31.7	26.0	30.7	33.6	29.4	32.4	27.5	33.2	28.4	34.8
Kootenai	"	11:00 A	65	31.4	26.4	31.5	25.7	30.6	32.1	29.1	31.5	27.6	32.7	27.8	34.1
Paradise	"	5:25 P	61	31.8	26.8	32.1	26.1	31.5	32.6	28.6	31.1	27.5	32.3	27.5	33.9
Missoula	7/2	12:15 A	55	30.5	27.1	31.0	26.4	30.5	32.2	28.4	30.5	27.2	32.0	27.4	33.5
Austin	"	7:30 A	61	29.8	27.1	30.2	26.3	29.2	31.3	28.2	29.8	27.2	31.3	27.3	32.7
Bozeman	"	2:20 P	67	31.7	28.0	32.1	27.0	31.8	31.6	28.5	30.3	27.2	31.5	27.6	33.0
Livingston	"	5:50 P	63	31.5	28.6	32.4	27.5	31.5	31.9	28.5	30.4	27.1	31.8	27.6	33.1
Laurel	"	11:30 P	57	31.7	28.7	31.9	27.9	31.2	31.7	28.4	30.1	27.0	31.5	27.5	33.0
Forsyth	7/3	6:15 A	60	31.0	29.1	31.6	27.8	30.7	31.8	28.9	30.1	27.3	31.7	27.9	33.1
Glendive	"	11:50 A	88	33.0	29.5	34.4	28.2	33.1	32.3	29.2	30.7	27.3	32.3	28.1	33.5
Dickenson	"	7:00 P	84	35.3	31.4	37.8	29.0	36.4	33.8	29.5	32.4	27.5	34.2	28.5	35.6
Glen Ullen	"	11:00 P	68	35.1	31.8	37.0	29.6	35.8	34.2	29.8	33.1	27.5	34.8	28.8	36.1
Windsor	7/4	7:00 A	72	34.3	31.9	35.9	29.5	34.6	34.0	29.9	32.8	27.5	34.5	29.1	35.5
Dilworth	"	4:00 P	88	36.0	33.0	38.0	30.5	37.0	35.0	31.5	34.0	28.0	35.8	30.3	36.9
Staples	"	9:15 P	74	37.0	33.9	39.0	30.9	38.0	35.9	31.9	35.1	29.2	37.0	30.7	37.7
Northtown	7/5	4:30 A	68	35.9	33.6	37.9	30.5	37.0	36.1	32.6	35.3	28.1	37.0	30.8	37.9
Winona	"	11:15 A	84	36.6	34.3	38.6	30.5	37.6	36.3	33.0	35.7	28.4	37.4	31.6	38.0
Savana	"	6:45 P	84	37.8	33.4	40.9	30.5	39.8	37.3	33.4	36.7	28.7	38.6	31.7	39.3
Morton Park	7/6	1:00 A	69	36.6	33.6	39.2	30.5	38.6	37.2	33.7	37.2	29.0	39.7	32.1	39.8

Table 7. Temperatures in Transit.
Car D: Dry ice in bulkhead above load.

Place	Date	Time	Outside temp.	Air				Under CO_2 container
				Doorway		Bunker		
				Top	Bottom	Top	Bottom	
Yakima	6/30	11:30 A	86	36.8	28.4	36.9	30.3	36.6
Do	"	1:45 P	83	36.1	27.8	36.9	31.1	36.9
Pasco	"	6:40 P	71	35.2	27.8	36.2	31.7	37.2
Lind	"	11:20 P	61	33.1	27.2	34.1	30.6	35.5
Yardley	7/1	3:50 A	55	31.8	26.7	32.7	30.0	34.4
" After Icing	"	5:00 A	56	32.4	26.9	32.9	29.9	33.9
Kootenai	"	11:00 A	65	31.7	25.7	32.3	29.3	33.1
Paradise	"	5:25 P	61	32.3	26.2	32.9	29.2	33.6
Missoula	7/2	12:15 A	55	30.9	26.6	31.6	28.8	32.3
Austin	"	7:30 A	61	30.6	27.0	30.8	28.2	31.5
Bozeman	"	2:20 P	67	32.5	28.1	33.0	29.0	35.3
Livingston	"	5:50 P	63	32.2	28.5	33.4	29.2	33.4

Table 8. Temperatures in transit. Car E: Check.

Place	Date	Time	Outside temp.	Air					Fruit						
				Doorway		Bunker		Beneath bulkhead opening (1)	Doorway		Bunker		Quarter-length		Top doorway south side car
				Top	Bottom	Top	Bottom		Top	Bottom	Top	Bottom	Top	Bottom	
Yakima	6/30	11:30 A	86	33.6	25.9	36.5	24.7	34.1	34.8	31.4	34.0	30.8	34.1	31.2	34.9
do	"	1:45 P	83	34.2	26.2	37.4	24.5	34.8	34.8	31.2	34.4	30.5	34.7	31.0	35.0
Pasco	"	6:40 P	71	33.9	26.4	37.3	24.9	35.0	34.8	29.9	34.5	29.2	35.0	29.2	35.1
Lind	"	11:20 P	61	32.7	26.0	35.5	24.8	33.5	34.1	28.6	33.9	27.9	34.9	27.6	34.5
Yardley	7/1	3:50 A	55	32.0	26.2	34.7	25.0	32.7	33.6	28.1	33.2	27.5	34.5	26.9	34.3
" After icing	"	5:00 A	56	32.2	26.5	35.3	25.3	32.7	33.5	28.1	33.5	27.9	34.1	27.0	34.0
Kootenai	"	11:00 A	65	32.4	27.0	35.5	25.5	33.4	33.0	27.9	33.1	27.1	33.9	27.0	33.6
Paradise	"	5:25 P	61	33.4	27.9	36.7	26.1	34.6	33.3	27.7	33.1	27.1	33.9	26.7	33.7
Missoula	7/2	12:15 A	55	32.9	28.7	36.0	26.5	34.0	33.2	28.0	33.1	27.1	34.1	27.0	34.2
Austin	"	7:30 A	61	32.4	28.4	35.1	26.8	32.8	32.8	28.3	33.0	27.5	33.8	27.2	34.0
Bozeman	"	2:20 P	67	34.0	29.6	37.5	27.6	35.2	33.3	28.9	33.4	28.0	34.1	27.7	34.1
Livingston	"	5:50 P	68	34.5	30.2	38.1	28.0	35.4	33.7	29.0	33.7	28.1	34.4	28.1	34.5
Laurel	"	11:30 P	57	34.0	30.6	37.3	28.2	34.9	33.7	29.4	33.8	28.2	34.5	28.2	34.9
Forsyth	7/3	6:15 A	60	33.9	30.5	36.8	28.5	34.0	34.0	29.9	34.4	28.5	35.0	28.7	35.1
Glendive	"	11:50 A	88	35.7	31.2	39.7	28.7	37.8	34.3	30.4	34.4	28.7	35.0	29.2	35.4
Dickenson	"	7:00 P	84	38.6	33.2	42.9	29.9	40.0	36.0	31.0	36.2	29.4	36.9	29.8	37.4
Glen Ullen	"	11:00 P	68	37.9	33.6	41.5	30.0	39.0	36.5	31.0	36.5	29.4	37.5	30.0	37.9
Windsor	7/4	7:00 A	72	37.6	33.7	41.0	30.8	38.0	36.7	32.0	37.5	30.0	37.9	30.5	38.5
Dilworth	"	4:00 P	88	38.3	34.5	42.3	31.3	41.1	37.2	32.8	37.5	30.5	38.1	31.7	38.9
Staples	"	9:15 P	74	39.5	35.0	43.1	31.4	40.5	38.0	33.4	38.3	31.3	39.0	31.8	39.5
Northtown	7/5	4:30 A	68	38.3	34.8	41.8	31.3	39.4	38.4	33.7	38.7	31.4	39.2	32.3	40.0
Winona	"	11:15 A	84	38.7	34.4	42.1	31.6	39.8	38.4	34.3	38.9	32.0	39.5	32.7	39.9
Savana	"	6:45 P	84	40.4	35.1	43.9	31.9	41.8	39.2	34.4	39.4	32.3	40.4	32.9	40.8
Morton Park	7/6	1:00 A	69	39.4	34.8	42.2	31.6	40.4	39.4	34.5	39.7	32.3	40.6	33.0	41.2

(1) In a position comparable to that beneath dry ice bunkers in cars C and D.

Table 9. Ice and Salt Used in Transit.

Place	Date	Time	Car A			Car B			Car C			Car D			Car E		
			Ice	Salt		Ice	Salt		Ice	Salt		Ice	Salt		Ice	Salt	
			lbs	lbs	%	lbs	lbs	%	lbs	lbs	%	lbs	lbs	%	lbs	lbs	%
Yakima	6/28	5:30 P	12,900	-	-	12,900	-	-	12,900	-	-	12,900	-	-	12,900	-	-
do	6/29	1:00 P	-	-	-	-	500	4	-	-	-	-	-	-	-	-	-
do	6/29	6:00 P	-	-	-	-	-	-	-	-	-	-	-	-	-	500	4
do	6/29	7:30 P	-	-	-	-	-	-	-	500	4	-	-	-	-	-	-
do	6/29	-	-	-	-	-	-	-	-	-	-	-	500	4	-	-	-
do	6/30	5:00 A	-	-	-	2,976	119	4	2,230	88	4	-	-	-	2,230	110	5
do	6/30	9:00 A	-	500	4	-	-	-	-	-	-	-	-	-	-	-	-
do	6/30	10:30 A	1,860	75	4	-	-	-	-	-	-	1,860	75	4	-	-	-
Spokane	7/1	4:00 A	1,860	74	4	2,750	110	4	3,200	128	4	2,400	96	4	3,359	168	5
Laurel	7/2	10:00 P	1,860	-	-	1,488	60	4	1,488	45	3	1,488	60	4	1,674	84	5
Dilworth	7/4	4:30 P	2,604	-	-	2,041	80	4	2,041	80	4	-	-	-	2,418	120	5
N. LaCrosse	7/5	1:30 P	-	-	-	800	32	4	700	35	-	-	-	-	900	36	4
Ice used to:																	
Laurel			5,580			7,204			6,918	-	-	5,748	-	-	7,263	-	-
Dilworth			8,184			9,246			8,959	-	-	-	-	-	9,682	-	-
N. LaCrosse			-			10,046 (1)			9,659	-	-	-	-	-	10,582	-	-
Salt added to:																	
Dilworth			-	649			869			841						982	

(1) In Car B fans for car precooling were operated during the afternoon of June 29, before, during and after the time of loading the car. Apparently about 700 pounds of ice for precooling.

Table 10. Weather Observations.

Date	Time	Temp. ° F.	Remarks	Date	Time	Temp. ° F.	Remarks
June 30	11:30 A	86	Overcast	July 3	4:30 A	55	Clear
	1:30 P	83	do		6:00 A	60	do
	3:00 P	86	do		11:20A	87	do
	4:30 P	85	do		1:30 P	91	do
	5:40 P	74	Clear		3:30 P	90	do
	6:40 P	71	do		5:20 P	87	do
	9:00 P	70	do		6:00 P	84	do
	11:30 P	61	do		7:00 P	84	Cloudy
July 1	3:00 A	55	Overcast		8:30 P	64	Storm
	5:00 A	56	do		11:00 P	68	Cloudy
	8:00 A	62	do	July 4	1:30 A	68	do
	10:00 A	65	do		5:30 A	73	do
	11:00 A	65	Light shower		7:00 A	72	Shower
	12:00	67	Overcast		9:30 A	64	Rain
	2:00 P	70	do		10:30 A	65	Cloudy
	5:25 P	61	Light shower		12:30 P	75	Clearing
	9:40 P	57	Overcast		2:00 P	86	Overcast
July 2	12:15 A	55	do		3:30 P	86	do
	4:30 A	55	do		4:00 P	88	do
	7:30 A	61	Partly cloudy		5:00 P	87	do
	8:30 A	65	Cloudy		6:30 P	85	Overcast
	11:00 A	68	do		8:30 P	74	Clear
	11:15 A	65	Mist		12:00	70	do
	1:30 P	73	Partly Cloudy	July 5	4:30 A	68	Rain
	2:20 P	67	Cloudy		9:45 A	80	Haze
	5:30 P	63	do		1:45 P	86	Clear
	7:00 P	67	Clear		3:00 P	90	do
	9:10 P	60	do		4:00 P	90	do
	11:30 P	57	do		6:30 P	84	do
				July 6	12:30 A	69	Clear

Influence of Raised Floor Racks on Refrigeration

For a period of approximately 60 hours between Glendive, Montana, and Northtown, Minnesota, the difference between the average temperature of the air at the top bunker opening and the average temperature of the air at the floor racks at the bottom of the bunker in car A (floor racks not raised) was 10.6° F., in car B (with dry ice placed as in car A) 9.7°; in car C (with dry ice in metal bunkers above the load) 7.4°; and in car E (check car, no dry ice) 11.3°. Owing to failure in thermometer equipment comparisons of air temperature differences at these positions cannot be made over a longer period of time.

Temperatures within the packages of fruit, referred to as "fruit temperatures," showed differences between the bottom and top (seventh) layers of packages at the bunker in keeping with differences in air temperature in the various cars. An average of these differences in "fruit temperature" between Yakima and Northtown were as follows: Car A (floor racks not raised) 4.6°; car B, 4.2°; car C, 4.8°; car E (check car) 5.9°. From these studies it cannot be concluded that raising the floor racks 4 inches above their normal position significantly influenced the circulation of air within the car.

Influence of Dry Ice Upon Refrigeration

Excepting at the time of the first observation the air temperatures at the top bunker opening were higher in the check car than in any of the cars containing carbon dioxide. Since 5 percent salt was used with the ice in the check car as contrasted with 4 percent or less in the cars supplied with dry ice, this would indicate that the refrigerating effect of the dry ice as placed in these cars was more than sufficient to offset any interference with air circulation or car refrigeration which might have resulted from the presence of the carbon dioxide.

Placing the dry ice in cribs in the ends of the car beneath the bunker bulkhead openings did not appear to affect the temperatures within the car to any great extent. While there was a very small difference in air temperature between the top and bottom bulkhead positions in car D, the air temperatures at the bottom of the bunker were not as low in that car as they were in the other cars, whereas the air temperatures at the doorway-floor rack position were similar to those in the check car, which had 5 percent salt instead of 4 percent as in the other cars. The air temperatures at doorway-floor rack position in car D were not as low as they were at similar positions in cars having the dry ice in cribs above the bracing at the doorway.

As far as can be ascertained from the data, the air temperatures immediately beneath the dry ice cribs in Car D and beneath the metal dry ice bunker in Car C were one or two degrees lower than they might have been without the dry ice. The lowering of the temperature at the top of the car makes these positions ideal for the use of dry ice insofar as refrigeration is concerned.

The lowest temperatures at floor rack positions prevailed in the cars having dry ice in cribs above the bracing at the doorway (Cars A and B). As far as can be determined from the data, the air temperatures at the doorway-floor rack position were from 1 to 3 degrees lower during the first two days than they might have been had the dry ice not been in the car. However, such variables as differences in fruit and car temperatures during loading, differences in time and manner of application of initial charges of salt and the insulating effect of the paper in car A, make it impossible to draw definite conclusions as to the refrigerating effect of the dry ice. The rate of sublimation of the dry ice in cartons

(table 2) indicates that less than 100 pounds was sublimated from the cartons per 24 hours. The refrigeration from this could approximate that from melting 200 pounds of water ice, which would not produce any marked difference in the temperature of the car as a whole.

The 144 pounds of dry ice which was broken up in the bunkers at Yakima, largely sublimated during the first 24 hours. For this reason its refrigerating effect was more marked during the first 36 hours than during the following period.

Owing to the low temperatures prevailing in car A (which was lined with Sisalkraft paper), the use of salt with ice was discontinued beyond Spokane, and the amount of salt added to car B was reduced to 3 percent at Laurel. Low temperatures continued to prevail in car A, so it is concluded that the special lining of paper and the additional air space above the load had a significant insulating effect.

From a study of the temperature records it appears that if dry ice is used according to the practices outlined above, with fruit precooled to 32°, not over 3 percent salt should be used at the initial icing. The temperature records confirm the work of Mallison and Powell, /1 which

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/1 Mallison, E. D. and Powell, C. L., "Refrigerated Transporation of Bartlett Pears from the Pacific Northwest." U.S.D.A. Tech. Bul. 434. 1934

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showed that with precooled fruit the use of salt should be modified from the regular practice of adding a definite percentage at the initial and subsequent icing stations. The records indicate that more uniform temperatures probably would have resulted if less salt had been added at Yakima and Spokane and more had been added at subsequent icing stations. The data suggest that when cherries are precooled thoroughly to 32°, where care is taken to keep cars cold while loading and when well-insulated cars are

used, not over 3 percent salt should be used at the initial icing and the first re-icing and that 5 percent salt should be used at subsequent re-icing stations; or, as Mallison and Powell have suggested, stated amounts of salt should be added at each icing station. They suggested 75 pounds of salt at each icing station, but they re-iced every 24 hours. When re-icing operations are spaced at intervals of 40 hours or longer, as was the case during this work, the stated amounts of salt should be greater than 75 pounds. Under conditions obtaining in this test, 140 pounds of salt per car would not have been too much to add at each re-icing station where dry ice was not broken up in the ice bunkers.

CONDITION AND APPEARANCE OF FRUIT AT DESTINATION

Test boxes from car D could not be observed as it was diverted from the Northern Pacific Railway at Laurel, Montana. The destinations of the test cars were: Car A, Minneapolis on July 5; cars B and C, Chicago on July 6; and car E, Pittsburgh on July 8. The fruit was inspected upon arrival of each car at destination.

Data on the condition and appearance of the test fruit are summarized in table 11. More decay developed during transit in the dark red cherries than in the less mature ones. The comparatively low concentrations of carbon dioxide maintained within the test cars failed to control decay in the inoculated fruit. Fruit of the light red maturity was more firm at destination but was not as sweet or full flavored as the darker colored lots. The test fruit in the gassed cars was generally brighter and the stems were greener than in the case of comparable fruit in the check car without gas.

The commercially packed fruit comprising the load proper was not of best shipping quality at point of origin, most of it having been picked

Table 11. Color and Condition of Fruit in Test Cars at Destination.

Car	Car Treatment	Destination	Kind of Test Fruit	Percent Decay	Color and Condition	General Remarks for Entire Carload
A	Gas	Minneapolis July 5	Light red		Stems green; fruit bright; flavor lacking.	Slight freezing injury in face of package at bottom bunker. Color of load bright. Occasional decay.
			Dark red		Stems green; fruit firm; good flavor.	
			Inoculated	4.0		
B	Gas	Chicago July 6	Light red	0.00	Stems green; fruit bright; flavor lacking.	40 boxes showed freezing injury 4 stacks out from bunker in the bottom layer. Color of fruit bright. Occasional decay. Load compared favorably with express shipments at auction.
			Dark red	2.00	Stems green; fruit good flavor	
			Inoculated	24.50		
C	Gas	Chicago July 6	Light red	0.00	Stems green; fruit lacks flavor.	Some freezing injury at bottom bunker. Fruit bright. Compared well with express car of similar fruit from same shipper. Sold 4 cents less per box. Occasional decay.
			Dark red	1.00	Stems green; fruit good flavor.	
			Inoculated	10.40		
E	Check	Pittsburgh July 8	Light red	1.50	Stems shriveled; fruit darkened.	Some freezing injury in bottom layer at bunker. About 10 percent decay. Load generally dark, but firm. Stems generally drier and more shriveled than those in gassed cars.
			Dark red	4.70	Stems shriveled - some dry. Fruit generally darkened.	
			Inoculated	17.20		

after rains and after having been held in storage for varying periods of time prior to loading. Due to the excessive rains there was more or less cracking of the cherries and an occasional decayed fruit was found prior to loading. In general, the condition and appearance of the fruit changed but little during freight transit in atmospheres containing carbon dioxide. The fruit compared favorably in color and condition with that from similar sources shipped by express two or three days later. On the Chicago auction, differences in price on the same day between fruit shipped by express July 2 and that shipped by freight under gas June 29 were small.

There was some freezing damage due to the precooling and the methods of refrigeration used. The effect of freezing was observed to the greatest extent in the bottom layer of car B. This car was loaded on the afternoon of June 29, but, unfortunately, due to complications of hurried loading at different points, temperature records were not secured for this car between that time and the morning of June 30. Since, however, temperatures subsequently were not as low in car B as they were in other cars, it is concluded either that freezing must have taken place before the dry ice was added; or, that, owing to the fact that the cherries in this car were less mature than they were in the other cars, they froze at a higher temperature. According to Wright [2] the freezing point of mature

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2/ Wright, R. C., "The Freezing Temperatures of Some Fruits, Vegetables, and Florists' Stocks." U.S.D.A. Circular No. 447. 1937.

Bing cherries varies from 23.4° to 24.3° F., whereas that of immature Bing cherries varies from 24.6° to 26.4°.

Observers Accompanying Test

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Northern Pacific Railway

Fred F. Fischer

Chicago, Burlington and Quincy Railroad

E. H. Ross

Fruit Growers Express Company

S. C. Belt